ANALYSIS OF WIRELESS TRANSMISSION LATENCY IN THE 2.4 GHZ AND 5 GHZ ISM UNDER LOAD OF NETWORK WITH DATA STREAM

Jan HART[1], Veronika HARTOVÁ[1], Martin KOTEK[1], Veronika ŠTEKEROVÁ[1]

[1]*Department of Vehicles and Ground Transport, Faculty of Engineering, Czech University of Life Sciences Prague*

Abstract
The Industry 4.0 initiative is currently a very topical and widely used notion, both in the area of information and communication technologies (ICT), academia and commercial sphere. This leads naturally to the development of new technologies that are designed to control and manage wireless terminal devices including data transfer. Some of these devices may be able to transmit large-capacity data, which considerably slows down the wireless network. The aim of this work was to analyze the risks associated with high-capacity data transmission through ISM bands, to find out the real latency of wirelessly transmitted data under different loads and to compare the efficiency of individual technologies from different manufacturers. It has been found that the real latency of wireless transmitted data reaches exponential dependence. At 150 Mbps the average latency of the tested technologies on the 2.4 GHz frequency band ranged from 220 to 255 ms and on the 5 GHz frequency band from 108 to 132 ms.

Key words: *latency; wi-fi; wireless network; ISM bands; frequency.*

INTRODUCTION

The Industry 4.0 initiative is currently a very topical and widely used notion, both in the area of information and communication technologies (ICT), academia and commercial sphere (*Piketty, 2015; Mařík, 2015; Dostál, 2017; Heřman, 2008*). From the side of "Industry 4.0" is the requirement that all attachable devices were connected to the internet to allow these devices to be remotely control, to be easier access to data sharing options or summarize of the data thus obtained, for example, a cloud storage is used (*Piketty, 2015; Mařík, 2015; Chang & Chen, 2017*). This leads naturally to the development of new technologies that are designed to control and manage wireless terminal devices including data transfer (*Han, Liang, Chen & Soong, 2016; Tahir & Shah, 2008; Oppermann, Stoica, Rabbachin, Shelby & Haapola, 2004*). Some of these devices may be able to transmit large-capacity data, which considerably slows down the wireless network (*Chang & Chen, 2017; Powell & Shim, 2012*). As a result, it can lead to latency eg. Driving instructions, where is the need for real-time processing (*Vlček, 2001; Šícha & Tichý, 1998; Dobeš & Žalud, 2006*). Before will be customized sophisticated devices are used, currently will be used at least initially available technologies such as wi-fi access points (*Tahir & Shah, 2008; Powell & Shim, 2012*).

Although the proposition of latency of data packets on wi-fi networks was pursued several authors, one did not address of direct latency of large data flows, but only simple date information (*Chang & Chen 2017; Gao, Ito & Shiratori, 2016; Krivchenkov & Sedykh, 2015*). Mostly, a direct endpoint response was addressed by analyze the data flow through ping commands, and the like (*Gao, Ito & Shiratori, 2016; Vikram & Sahoo, 2017*).

Another important aspect is to answer the question whether specialized systems for mass-data transmission can will defend the usual wi-fi solution from common Wi-Fi access point manufacturers and whether common wi-fi systems can be included in the "Industry 4.0" concept or it will need to use specialized technologies designed specifically for this purpose in the future.

The aim of this work was to analyze the risks associated with high-capacity data transmission through ISM bands, to find out the real latency of wirelessly transmitted data under different loads and to compare the efficiency of individual technologies from different manufacturers.

MATERIALS AND METHODS

The devices were tested in a local network consisting of a router and a switch. Wi-fi access points will be connected through the switch. Then, a data traffic generator is connected to the network, and a system through which the maximum network throughput and latency of flow of high capacity data. This connection and measurement will be repeated for different access point models. For measurements were used the following devices:

- Generator of network traffic on LAN
  - Tester XtendLan ETHERTEST100G
- Tester of network availability, transmission errors and response times
  - PingerPlus (manufactured by Psiber)
- Router to create a local network
  - ASUS RTAC86U
- Switch to connect the network on the router
  - Cisco SG110D-05
- Wifi access points with client function
  - (tab. 1)

Tab. 1 Wifi access points with client function

Wifi access point	Frequency [GHz]	Speed [Mbps]
CAMIBOX-SET_M1-C2	5	100
MikroTik RBwAPG-5HacT2HnD	2,4 + 5	300 + 1300
Ubiquiti NanoStation M2 Loco	2,4	150
TP-LINK CPE220	2,4	300
Ubiquiti NanoStation M5	5	150
TP-LINK CPE520	5	300

The wiring topology (fig. 1), where the router is connected to the WAN (Internet) and also to the switch. To this is connected tester for testing latency PingerPlus and one of two identical wifi access points. Further, the Wifi access point is wirelessly connected to a second identical access point that is connected to a network traffic generator.

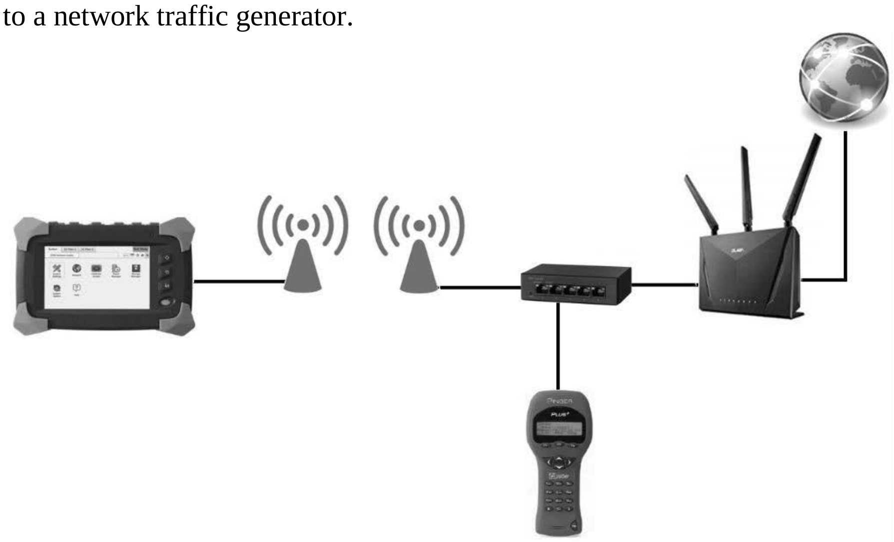

Fig. 1 Topology of wiring of test file

By each measurement was performed 20 repetitions. At the end of the results created average values, which have been further processed. The data flow was chosen to respect the maximum transmission capabilities of each device (1–150 Mbps). A base scale was created that was divided by 10 Mbps. At each measurement was on generator of traffic on LAN network created communication about that volume of data through TCP protocol. This generator was connected to the access point, which sent the data to the same type of device that was 10 m away from it (direct view) and was connected to the switch. This data communication was targeted (routed) to the router, which was also connected to the switch. Size of latency transfer was monitored by the tester network availability, transmission errors and response times. It verified this latency by function ping and from which individual results were recorded.

RESULTS AND DISCUSSION

From the measured values, several fundamental things can be concluded. The results show that the maximum transmission rate for the individual devices does not affect the resulting of latency. Both of the frequency of 2.4 GHz and at 5 GHz is from the transmission amount of data of 50 Mbps constant of latency. When exceeding 50Mbps latency value increases sharply (fig. 2, fig. 3). We can also conclude from these graphs that apart from the access points from MikroTik manufacturer, individual products from the same manufacturer are on the same level. This means that we cannot say that TP-LINK has products with better quality than Ubiquiti because although it was better in the 5 GHz bands, it was worse in the 2.4 GHz bands.

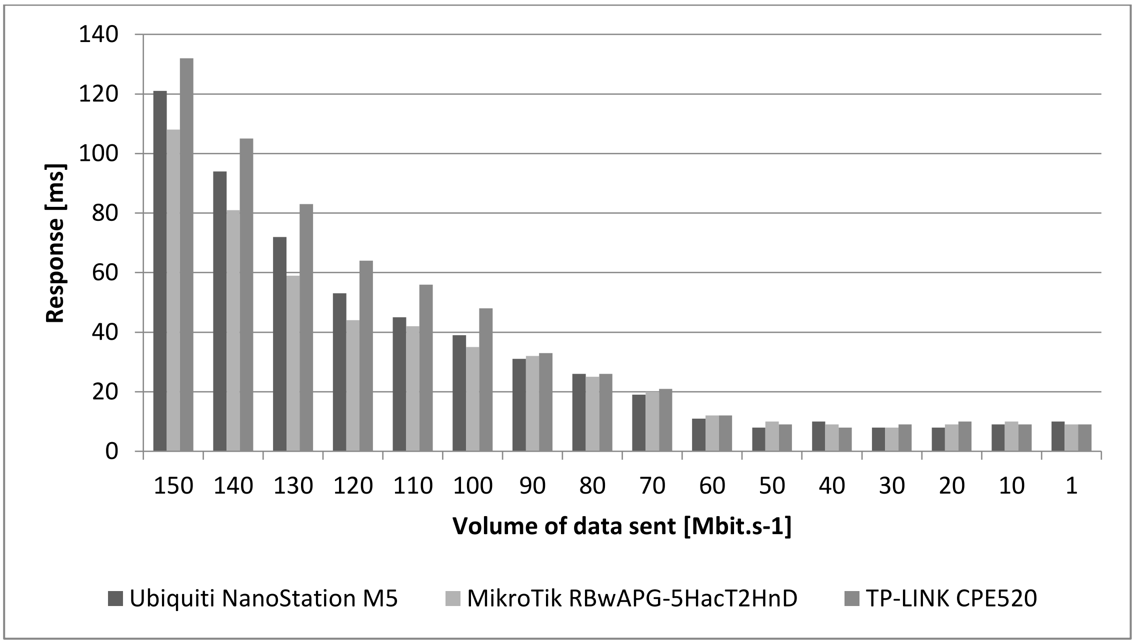

Fig. 2 Testing access points at 5 GHz frequency

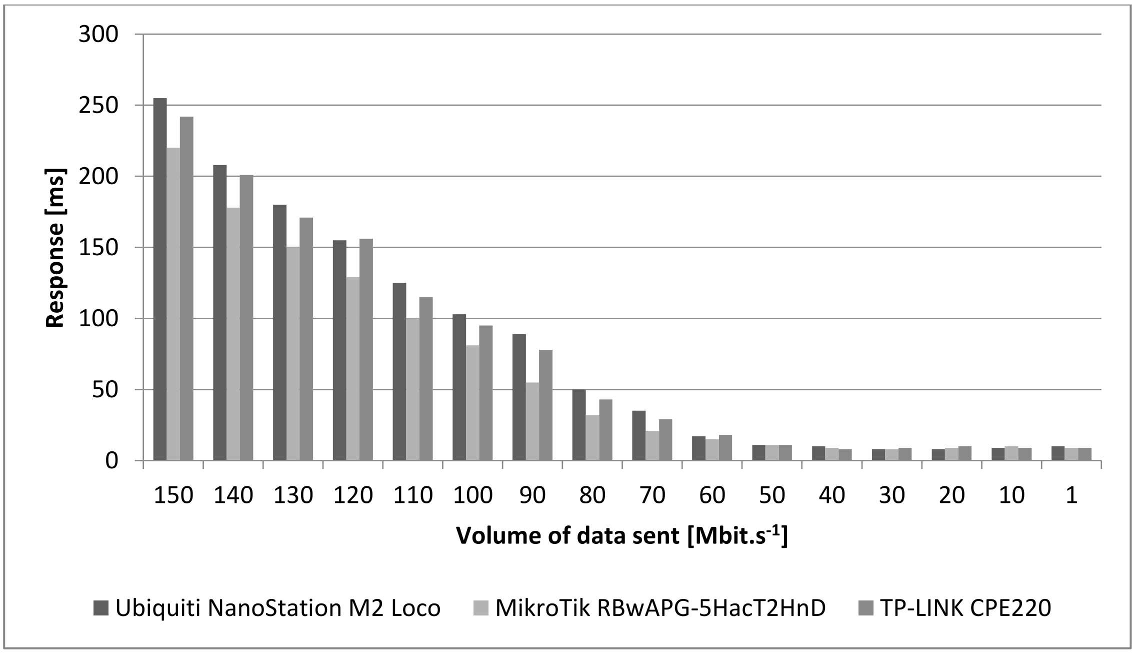

Fig. 3 Testing access points at 2,4 GHz frequency

They were also addressed values for the ISM 2.4GHz, and 5GHz ISM for all the products tested, including professional product variants CamiBOX (fig. 4).

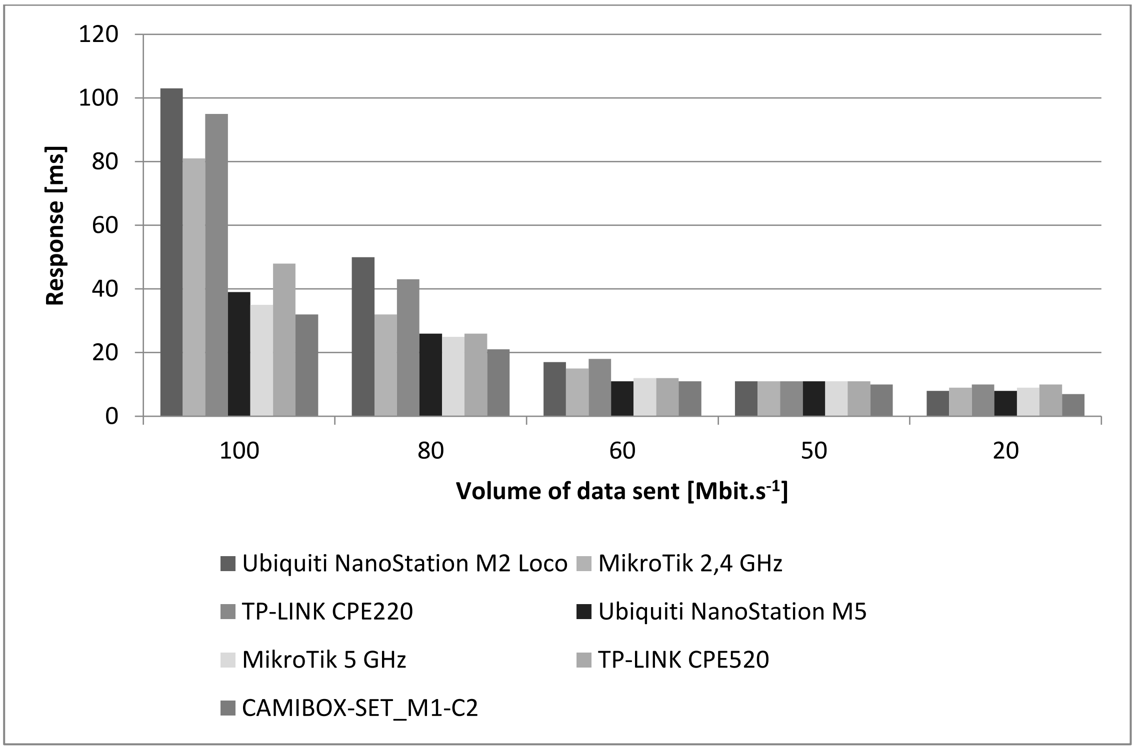

Fig. 4 Comparison of Standard Access Points with Professional Version

Latencies that arise from wireless over wifi are still a problem. Individual scientists are trying to minimize latency in wireless devices through various methods. For example, QAir has a different approach to transfer the distributed queue to the host queue and can reduce the average wifi latency by 50-75% (*Pei, Zhao, Liu, Tan, Zhang, Meng & Pei, 2017*). Another similar process is described by the authors of the article "Uplink ultra-reliable low latency communications assessment in unlicensed spectrum", where they are looking for an alternative to reduce the resulting transmission latency (*Cuevas, Rosa, Frederiksen & Pedersen, 2018*).
In practice, we mostly encounter classic old wifi technologies, through which users also want to control individual automation elements. The problem is that for some operations that require real-time control, latency can cause considerable trouble. Thanks to the exponential increase in latency due to the volume of transmitted data via wifi, it is necessary that at the time of such broadcasting there is no excessive data transmission. Otherwise, the desired operation may be delayed, which can lead to decisive consequences.
Wifi is increasingly used in IoT applications and many others where wireless data communication between two or more devices is needed. The size of IoT data is not fixed. There is an effort to minimize them, but it can also be data in tens or hundreds of MBytes (simple binary commands - bits, video and audio records - tens to hundreds of MBytes, etc.). One such application is the idea of communication between vehicles where individual vehicles exchange information with each other. This communication can lead to more effective information about the accident, traffic and location of the vehicle (*Guan, He, Ai, Matolak, Wang, Zhong & Kurner, 2019*). It is therefore important that the latency of data transfer was minimal, as at increased latency threatens to limit of size the transmission of messages due to the range wifi and movement of vehicles. This also affects the fact that it is time consuming to connect with the wifi access point (*Pei, Wang, Zhao, Wang, Meng, Pei, Peng, Tang & Qu, 2017*).
Similar tests have been addressed in article "Hybrid Communication Architectures for Distributed Smart Grid Applications", although this was strictly related to low-energy communication with photo-voltaic

panels. Even so, this article presents the results latency UDP transmissions depending on the size of packets sent (*Zhang, Hasandka, Wei, Alam, Elgindy, Florita & Hodge, 2018*).
Until a new technology is developed, wifi technology is currently the most widely used wireless local area network technology, so it is important that its testing and improvement does not cease and, on the contrary, continues to grow.

CONCLUSIONS

The results showed that the real latency of wireless transmitted data reaches exponential dependence. At 150 Mbps the average latency of the tested technologies on the 2.4 GHz frequency band ranged from 220 to 255 ms and on the 5 GHz frequency band from 108 to 132 ms.
According to the results it can be stated that the professional CAMIBOX product, which is used for industrial data transmission, has achieved the best results. The second in terms of lowest latency was the manufacturer MikroTik, who achieved similar results to CAMIBOX. Other tested devices TP-LINK and Ubiquiti reached inconsistent results with worse latency than previous devices.
In the future, it is contemplated to continue in testing, taking into account the size of the test packets, and the possibility of using other network topologies as well as extending the number of transmitters to more accurately determine to what extent the latency is dependent on the number of devices on the network.

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Corresponding author:
Ing. Jan Hart, Ph.D., Department of Vehicles and Ground Transport, Faculty of Engineering, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6, Prague, 16521, Czech Republic, phone: +420 734170850, e-mail: jhart@tf.czu.cz